

The DZERO Rack Monitor Module

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1.0 INTRODUCTION

A general purpose monitoring module has been designed for acquiring hardware monitoring data from the D0 facility. This module will be used to measure parameters such as temperatures and power supply voltages on the platform and in the movable counting house.

The design goals were to implement a small module with enough capacity to satisfy the monitoring requirements of a single relay rack and to connect of these modules to a control system VMEbus crate over a single cable. Because of noise considerations, no processors or clocks are allowed on the D0 detector platform. Therefore, the monitor chassis must be a "dumb" device.

2.0 GENERAL DESCRIPTION

The monitor chassis includes both analog and digital, input and output. The majority of the D0 monitoring requirements are for analog inputs used to interface temperature sensors, power supply voltage and current monitors. Specifications for the module are given in Table 1. Figure 1 is a block diagram of the module.

Physically, the monitor module is housed in a small self-powered rack mounted chassis. All I/O connections are made using "D" type connectors at the back panel of the chassis. Sixteen differential A/D inputs are available on each of four 37-pin connectors. Four words of digital data are also interfaced to each of four 37-pin D connector. The 16 bits of data from a single connector are arranged to provide alternate signal and ground conductors in an attached ribbon cable. A one microsecond positive strobe signal is included in each digital I/O connector to indicate when data is read or stored by the control system. Multiple word transfers to and from the digital I/O connectors are supported, and the word count for each word is given on five pins of the digital connectors. The counter can be disabled by front panel switch. The data direction for each of the four words of digital I/O is switch selectable by a segment of a front panel piano dip switch. Two 9-pin D connectors are used for eight D/A output signals. On the Rack

Monitor chassis, all input-output connectors are socket type.

The monitor chassis is connected to the control system using the MIL-STD-1553B multiplexed data bus standard. This protocol allows several chassis to be daisy-chained together using a single shielded twisted pair cable to connect to a MIL-1553B controller that is located in a VMEbus control crate.

3.0 PHYSICAL CHARACTERISTICS

The Rack Monitor is contained in a 1 U (1.75") x 19" rack mountable chassis. All output signals are available on the rear panel and status indicators are located on the front panel. Several switches and an AC line fuse are also accessible from the front of the module.

3.1 The Front Panel

Figure 2a is a diagram of the front panel of the Monitor Module showing the indicator LEDs and the address/mode-control switches. In addition to the power supply indicator LEDs (for the +5, +9, +15 and -15V supplies), LEDs are included to show "*Module Select*", "*Module Reset*" and "*Oscillator Power*"

Module Reset is driven by a retriggerable one-shot that will cause a reset to occur if the module has not been addressed for about 10

Analog:		
Input:	-No. of Channels	64 Differential
	-Input Range	-10 to +10 volts
	-Input Resolution	12 Bits
	-Overvoltage Protection	35V to gnd, Max.
	-Input Impedance	>10 Megohms
	-Source Impedance of Inputs	2 Kohms
Output:	-No. of Channels	8
	-Output Voltage Range	-10 to +10 volts
	-Output Current	5mA
	-Resolution	12 Bits
Digital I/O[†]:		
	-No. of bits	64 (4-16 bit words)
	-Input Levels	TTL
	-Strobe Width [§]	1 μ s nom.
Interface to Control Computer:	MIL-STD-1553	
Power Input:	90-130VAC 30 Watts Typ.	
<p><i>Notes: § Strobes indicate when data is read or written. Output data is valid on the trailing edge of the one microsecond positive strobe (high to low transition).</i></p> <p><i>† Data direction of each word is set by a front panel switch.</i></p>		

Table 1. Rack Monitor Specifications

seconds. This signal only resets the MIL-1553B interface circuit and not the latched D/A or digital output data.

Piano-dip switches are accessible through the front panel. An *open* (switch in the up position) corresponds to a logic "1". Five bits are used to set the RT address of the module. Each module on a given MIL-1553B bus must have a unique address. Four switch sections control the data direction of the digital I/O data, and other switches inhibit the digital I/O counter and select between the continuous and pulsed oscillator power modes.

3.2 The Rear Panel

All I/O connections to the rack monitor chassis are made through 37-contact socket type "D" connectors on the rear panel. As shown in Figure 2b, the chassis has an upper and a lower group of connectors that are mounted to the circuit board in the chassis.

Pinouts of all analog and digital I/O interface connectors are given in Figure 3. These figures include the conductor number of each signal in an attached ribbon cable as well as the pin number of the D-type connector on the chassis.

4.0 MIL-STD-1553B

MIL-1553B is a definition of a 1 MHz serial multiplexed data bus that operates over a single shielded twisted pair cable. Because it is a standard, the necessary protocol interface circuits are commercially available as integrated circuit controllers.

Data transfers over the MIL-1553B bus are command/response type of communication. A command is sent out by a VMEbus controller to the Remote Terminal (RT) and a status word response is returned by the RT. Data immediately follows the command word or the status word depending on the direction of the data transfer. The data acquisition chassis described here functions as a MIL-1553 RT. Data within the RT are accessed by specifying the RT address, the subaddress within the selected RT, the number of words and the direction of the data transfer. All of these parameters are included in the sixteen bit command word sent out by the controller to initiate the transfer. The MIL-1553B LSI protocol chip searches for common error types such as timing errors, invalid commands, parity errors, lack of response, response from the wrong RT address, and hardware signaling errors.

The monitor chassis is designed to be a direct coupled Remote Terminal device that operates according to the MIL-STD-1553B specification. The direct coupled design causes multiple modules to be connected to the controller as a daisy chain, using the appropriate single shielded twisted pair cable. The transformer coupling dictated by the MIL-1553B specification eliminates ground currents between multiple RTs. The two twinax connectors needed for the daisy chain connection are shown in Figure 2b.

Use of the MIL-STD-1553B for these modules has many advantages:

- Several modules (between 1 and 30) may be driven from a single controller module in a VMEbus crate.
- Each MIL-1553B bus requires only a single cable.
- Each Remote Terminal is isolated from the bus by the transformer-coupled

connection required by the specification.

- The MIL-1553B bus is inactive when data is not being transmitted. That is, the specification does not include a continuously running clock on the bus cable.
- Because MIL-1553B is a standard, reliable LSI interface circuits are available to handle the protocol.
- The MIL-1553B specification supports "dumb" remote terminals. That means no processor is required in the RT.
- The MIL-1553B Remote Terminals can be located near the data sources which may be up to a few hundred feet from the controller.

5.0 I/O INTERFACE

This section describes the characteristics of the I/O interface.

5.1 Analog Input

The A-D input is designed for high level analog signals within a -10 to +10 volt range. Although the chassis presents a high input impedance to the attached signals, the usual capacitive characteristics of these multiplexed inputs requires the signal source impedance to be 2 kohms or less to preserve the 12-bit accuracy of the system. Each analog connector provides for sixteen differential input signals.

Pins 17,18, and 19 of the analog input connector may be jumpered to +5 volts. This is intended to operate low power temperature sensors such as the National LM-34. Short circuit protection is provided by a 50 ohm resistor in series with the +5 volt supply.

A word of caution: Although the differential input voltage has a range of $\pm 10V$, the sum of the differential and common mode voltages should not exceed $\pm 10V$ on either input. For example, an isolated 1.5V battery attached to an input channel may drift to a common mode voltage near 10V resulting in an incorrect reading of the battery voltage.

5.2 Analog Output

Four analog output signals are available on each of two 9-pin D connectors. These D-A outputs can source 5 ma in the range -10 to +10 volts with a resolution of 12 bits.

5.3 Digital Input/Output

There are four words of digital I/O data accessed by four 37-pin connectors. Data direction of each word is separately selected by a front panel switch piano DIP switch. For a given connector, a switch in the up position corresponds to input. When a port is selected for digital output, data bits are written into "readback" latches so that the output data may be read by the computer. This feature is necessary in order to be able to set or clear individual bits in the output word. The same sub-address is used to write or read a given output word.

The pinout of the digital output connectors was arranged to allow direct connection to OPTO22 I/O modules. Pin 17 of these connectors provides +5 volts to drive the OPTO22 modules. Pin 18 of the output connector is a strobe signal that indicates when data is written to the output port. New data is stable on the trailing edge of the strobe.

When a digital word is selected for input, each bit is internally pulled up to +5V with a 10 kohm resistor so that an isolated external switch contact can be used as an input bit.

Note that, multiple word MIL-1553B commands can be used to read or write several words to a selected digital port. For each new word, a 5-bit counter is incremented to indicate the number of the word being read or written. This counter begins at zero for the first word, and counts up for succeeding words. As shown in the connector pinout diagram, the counter bits 4..0 are connected to pins 37..33 of the digital I/O connectors. The counter may be disabled by setting the front panel counter disable switch to its down position. To read multiple words into a single digital port, the counter bits may be used by the external equipment to multiplex data onto the data lines.

Multiple words may be written to external equipment by using the counter bits to address the registers and storing data in the selected

register on the trailing edge of the positive 1 μ s strobe pulse.

6.0 OPERATION OF THE MONITOR

The Monitor Module appears to the MIL-1553B controller as a normal MIL-1553B Remote Terminal that makes use of the sub-addresses given in Table 2. The operation of the digitizer requires that the desired starting channel number be sent before the A-D is read out. This allows any selected group of channels to be read from the 64 channels that are available. The starting channel is sent using the "Synchronize Mode Code with Data" command, a command that can be sent to a selected RT address or to all the RTs on a given bus using the broadcast address (\$31).

The A-D immediately digitizes the channel indicated by the Synchronize data. A subsequent multiple word transmit command sent to a specific RT address and subaddress number 20 (\$14), will cause the monitor module to return requested data. Because the maximum word count allowed by the MIL-1553B specification is 32, two transmit commands are required to read all 64 analog channels in a single module. The D-A settings and access to the digital I/O data is accomplished using one word transfers listed in the Table 2.

Subaddress \$1E accesses information from an ID/Status register in the monitor. The upper byte of this word contains an 8-bit identification number that is defined by cut-trace options on the board at the time of manufacture. This byte can be read by the control computer and compared with the expected value, a feature that is particularly useful for a chassis that are part of a large system. Front panel switch information is returned in the low byte of the ID/Status register word; bit 6 is the oscillator switch status (0 = Oscillator ON), bit 5 is the counter status (0 = Counter OFF) and bits 4..1 are the data directions of digital data on connectors P8, P3, P7, and P2, respectively (0 = OUTPUT, 1 = INPUT). For all front panel piano dip switches, 0 = switch in the *down* position, 1 = switch in the *up* position

Subaddress	T/R	Word Count	Description
\$01	0 (1)	1	D-A 0 P4-1 (<i>T/R=1 reads D-A setting</i>)
\$02	0 (1)	1	D-A 1 P4-2
\$03	0 (1)	1	D-A 2 P4-3
\$04	0 (1)	1	D-A 3 P4-4
\$05	0 (1)	1	D-A 4 P9-1
\$06	0 (1)	1	D-A 5 P9-2
\$07	0 (1)	1	D-A 6 P9-3
\$08	0 (1)	1	D-A 7 P9-4
\$09-\$0F	x	x	Not Used
\$10	1 or 0	0-\$1F	Digital I/O P3 (<i>TR=1,input; 0=output</i>)
\$11	1 or 0	0-\$1F	Digital I/O P8
\$12	1 or 0	0-\$1F	Digital I/O P2
\$13	1 or 0	0-\$1F	Digital I/O P7
\$14	1	0-\$1F	Read A-D Data P5, P6, P10, P11
\$15-\$1D	x	x	Not Used
\$1E	1	1	Status/ID word
\$1F	0	\$11	Synchronize Mode Code with Data (Data is Starting A-D Ch. No.)

Note: T/R = 1 for a read operation; T/R = 0 for a write

Table 2. Valid MIL-STD-1553B Commands for the Rack Monitor RT

The module Remote Terminal (RT) address is set by front panel switches. Note that the switch value is only read into the interface chip at *power-on* time or at *reset* time. Therefore, if an RT switch bit is changed while the monitor is in use, the new address will not become active unless the MIL-1553B transmissions are interrupted for about 10 seconds, or the power to the monitor is cycled. Of course, each Rack Monitor on a given bus must have a unique address. Duplicate addresses will cause errors on the bus.

7.0 Oscillator Power

An option was included to allow the oscillators, required to operate the MIL-1553B interface

and the A-D converter, to be powered down during periods of inactivity. In this mode, the oscillator power would turn off a preset time following the last activity on a given 1553 cable. The oscillators turn on slowly, so a dummy transmission would be required to reactivate the oscillators. Switching between the oscillator power modes requires moving one chip on the circuit board. At the present time, the software does not support the pulsed power mode and it is expected that the pulsed mode may not be used. In any case, use of this mode would probably require data acquisition at less than the current 15 Hz rate.



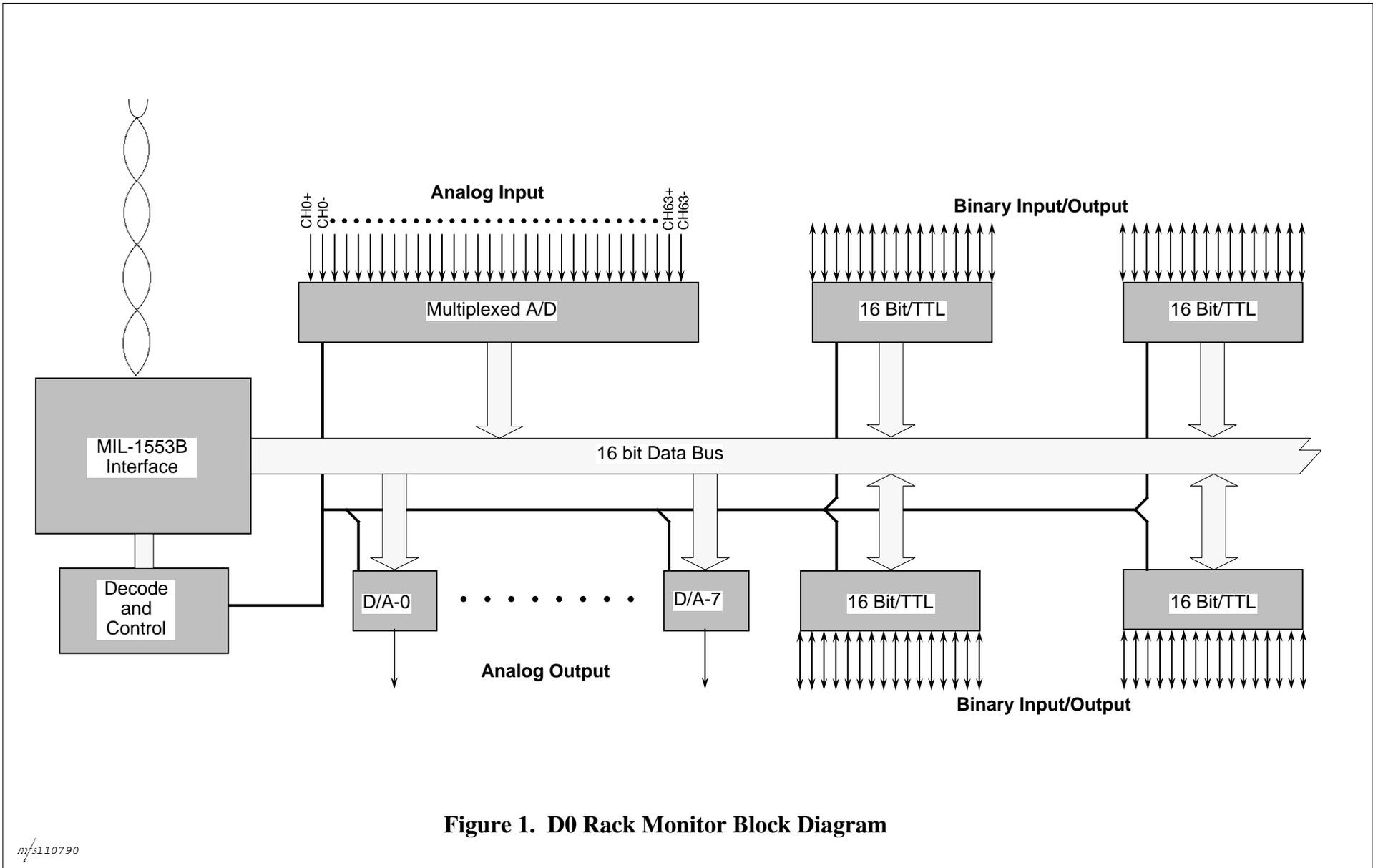


Figure 1. D0 Rack Monitor Block Diagram

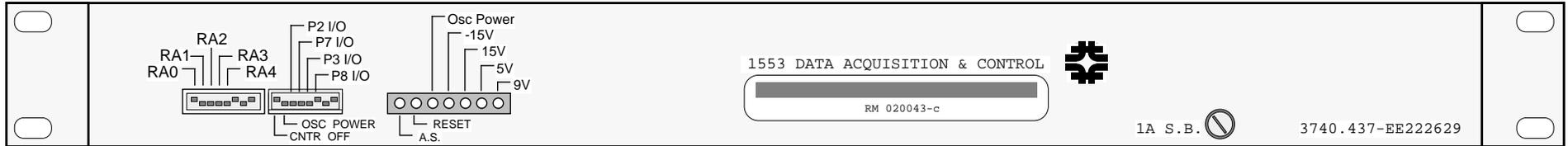


Figure 2a.

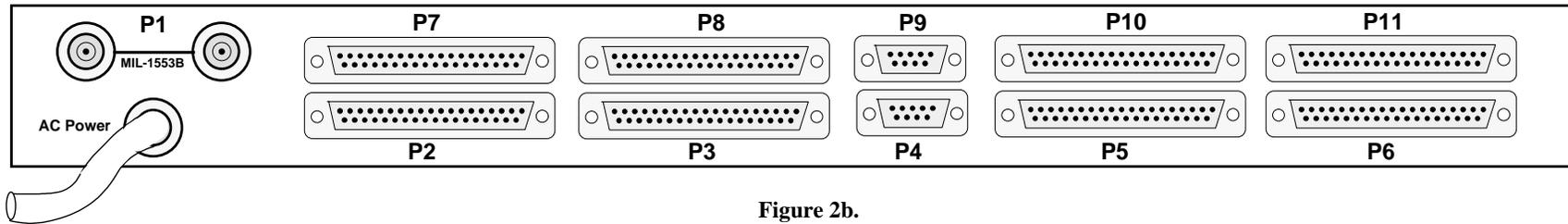
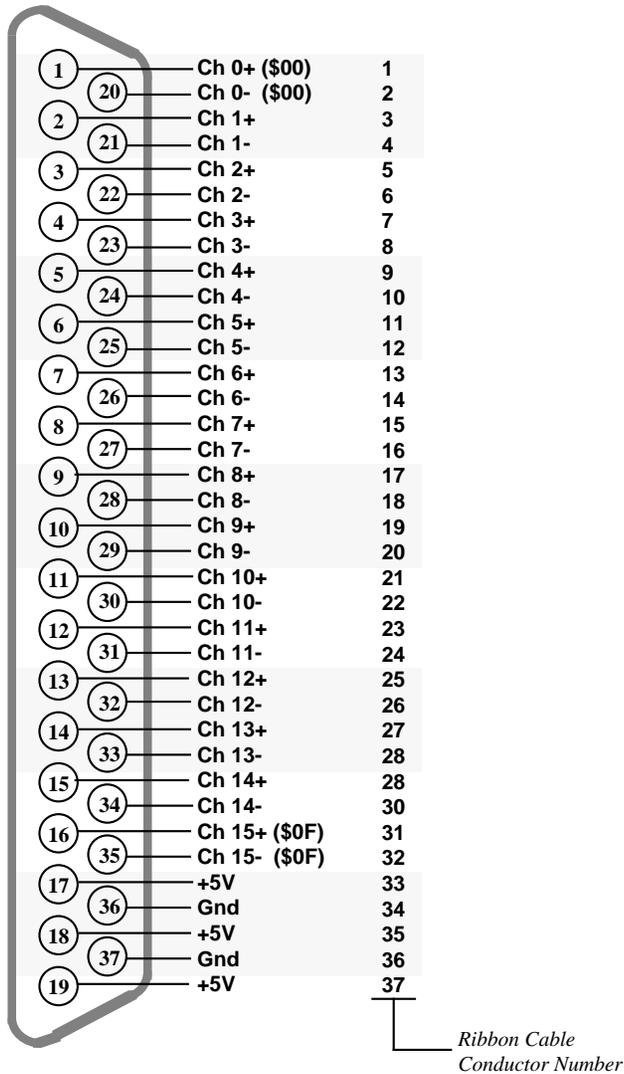


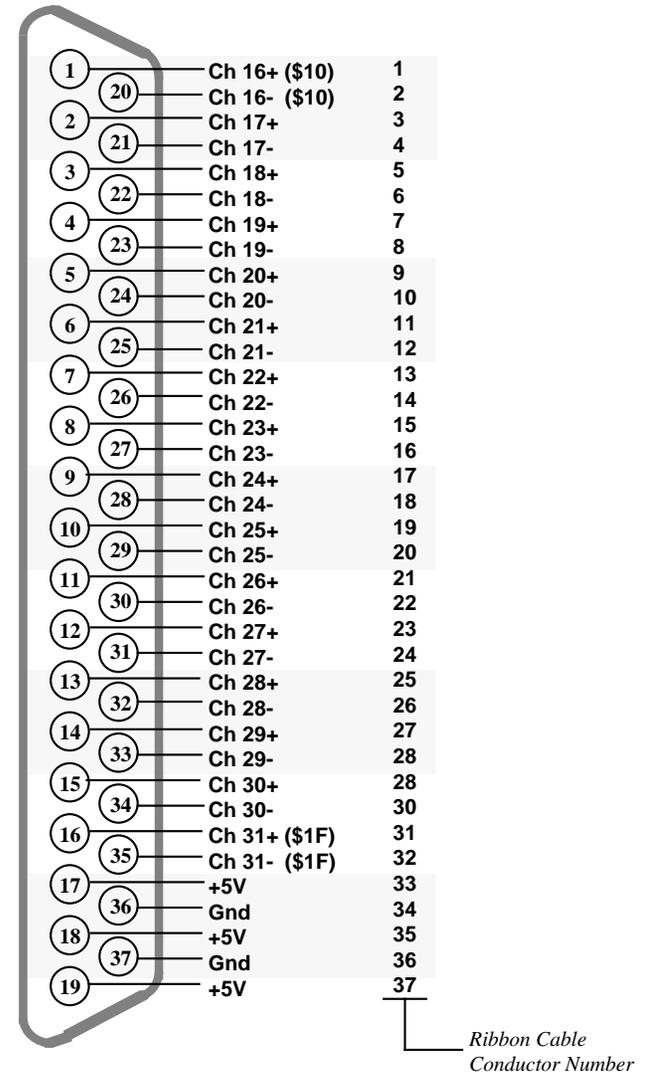
Figure 2b.

Figure 2. Rack Monitor Front and Rear Panel Diagram



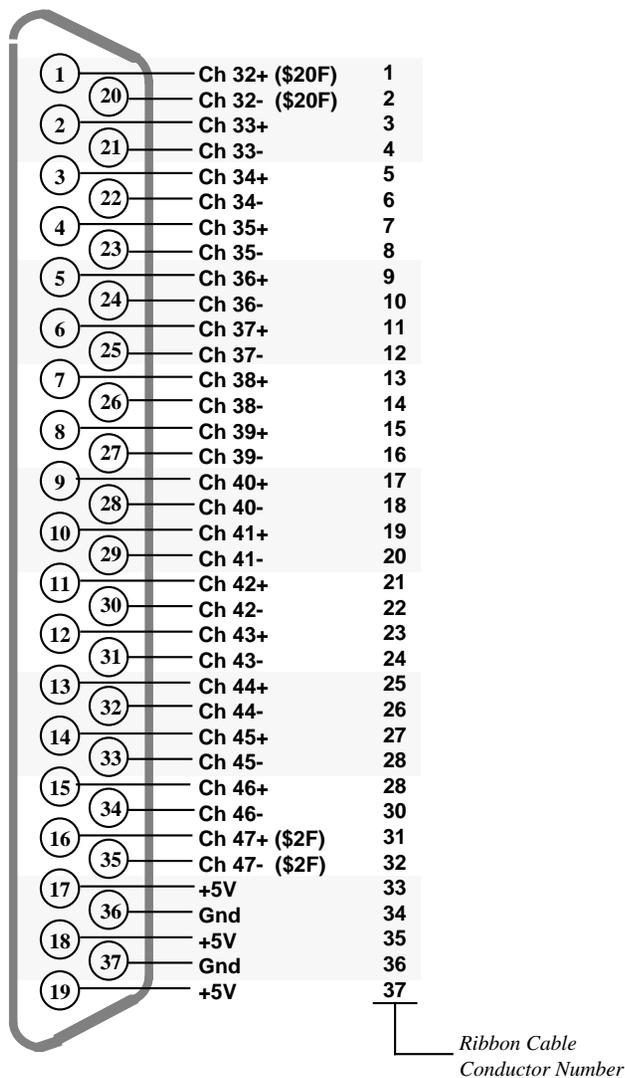
Note: +5V on Pins 17, 18, and 19 is optional

Figure 3a. Analog Input Connector P5
37-Socket "D" Connector Pinout



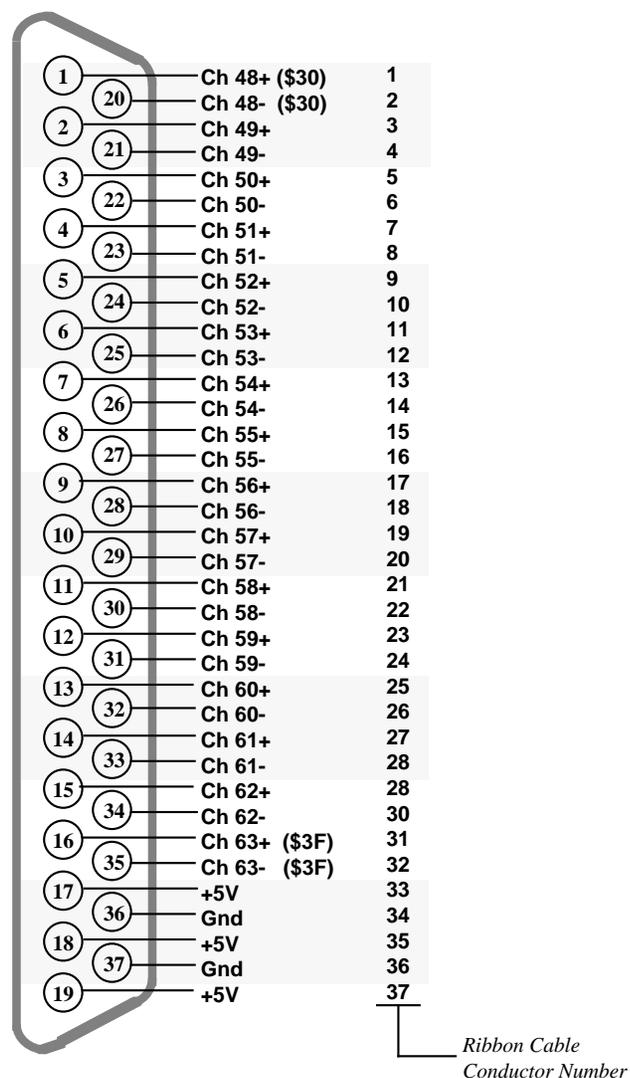
Note: +5V on pins 17, 18, and 19 is optional

Figure 3b. Analog Input Connector P6
37-Socket "D" Connector Pinout



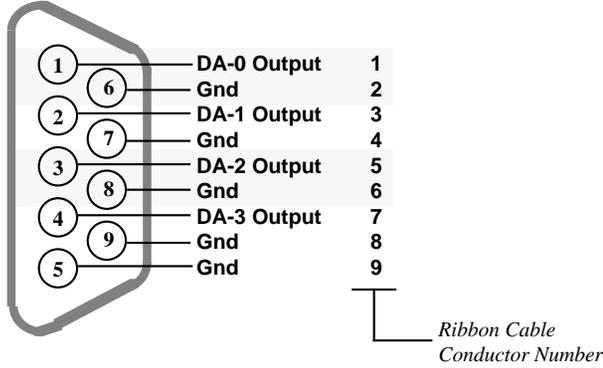
Note: +5V on pins 17, 18, and 19 is optional

Figure 3c. Analog Input Connector P10
37-Socket "D" Connector Pinout

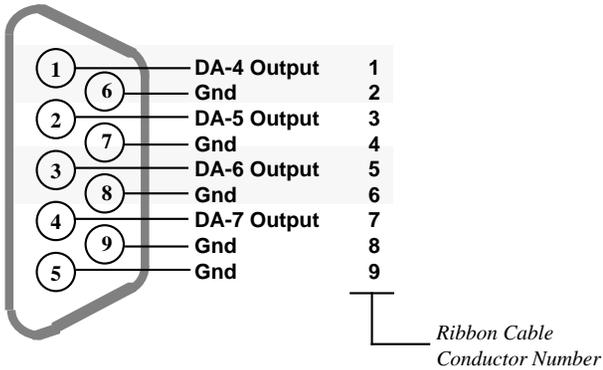


Note: +5V on pins 17, 18, and 19 is optional

Figure 3d. Analog Input Connector P11
37-Socket "D" Connector Pinout

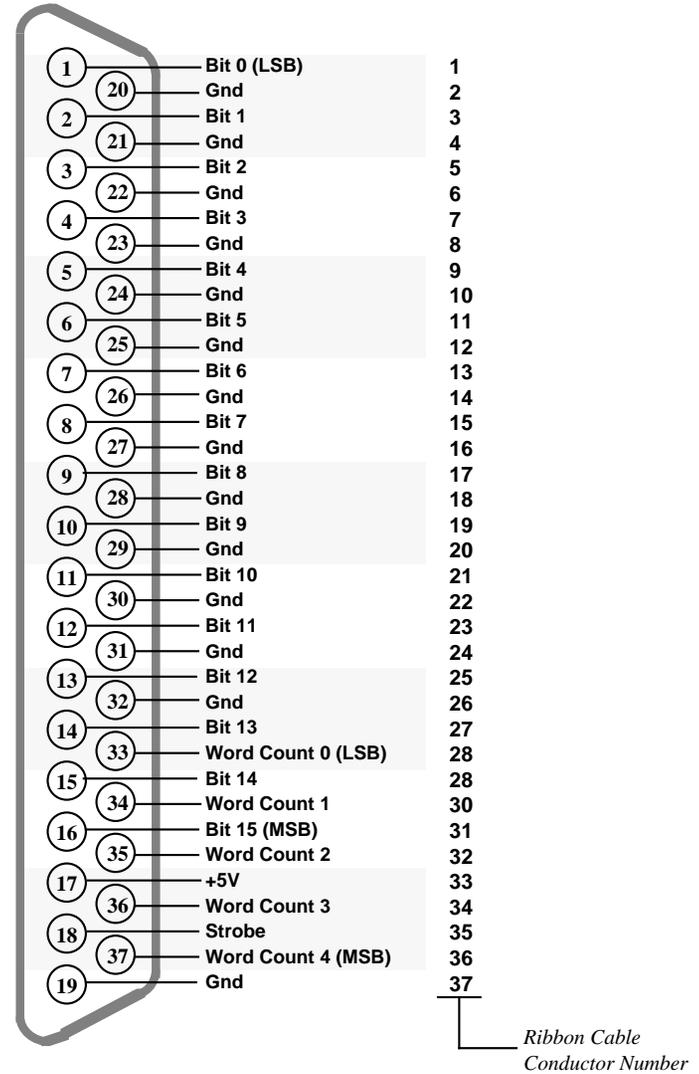


Connector P4



Connector P9

**Figure 3e. Analog Output Connector
9-Socket "D" Connector Pinout**



Note: Data Direction of each digital I/O word may be selected separately

**Figure 3f. DZero Rack Monitor P2, P3, P7 and P8
Digital Connector Pinout**

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Item	QTY	Part Name	Manufacturer	Part Number	description	RefDesignator	Dist/stknum	unit cost	qty 1	cost 25
1	2	Resistor	YAGEO		51 OHM 1/4W 1%	R54,55	49.9XBK-ND	\$0.06	0.12	\$3.00
2	5	Resistor	YAGEO		150 OHM 1/4W 1%	R24,34,35,44,45	150XBK-ND	\$0.06	0.3	\$7.50
3	3	Resistor	YAGEO		220 OHM 1/4W 1%	R76,77,79	220XBK-ND	\$0.06	0.18	\$4.50
4	5	Resistor	YAGEO		330 OHM 1/4W 1%	R6,7,8,14,33	330XBK-ND	\$0.06	0.3	\$7.50
5	1	Resistor	YAGEO		390 OHM 1/4W 1%	R21	390XBK-ND	\$0.06	0.06	\$1.50
6	2	Resistor	YAGEO		470 OHM 1/4W 1%	R3,11	470XBK-ND	\$0.06	0.12	\$3.00
7	1	Resistor	YAGEO		680 OHM 1/4W 1%	R28	680XBK-ND	\$0.06	0.06	\$1.50
8	4	Resistor	YAGEO		1K OHM 1/4W 1%	R12,36,37,46	1.00KXBK-ND	\$0.06	0.24	\$6.00
9	1	Resistor	YAGEO		1.2K OHM 1/4W 1%	R2	1.21KXBK-ND	\$0.06	0.06	\$1.50
10	2	Resistor	YAGEO		2.2KOHM 1/4W 1%	R4,5	2.21KXBK-ND	\$0.06	0.12	\$3.00
11	1	Resistor	YAGEO		3.9K OHM 1/4W 1%	R9	3.92KXBK-ND	\$0.06	0.06	\$1.50
12	1	Resistor	YAGEO		6.8K OHM 1/4W 1%	R20	6.81KXBK-ND	\$0.06	0.06	\$1.50
13	1	Resistor	YAGEO		27K OHM 1/4W 1%	R10	27.4KXBK-ND	\$0.06	0.06	\$1.50
14	4	Resistor	YAGEO		100K OHM 1/4W 1%	R22,41,50,57	100KXBK-ND	\$0.06	0.24	\$6.00
15	3	Resistor	YAGEO		270K OHM 1/4W 1%	R13,18,19	274KXBK-ND	\$0.06	0.18	\$4.50
16	1	Resistor	YAGEO		390K OHM 1/4W 1%	R23	392KXBK-ND	\$0.06	0.06	\$1.50
17	2	Resistor	YAGEO		1.0M OHM 1/4W 1%	R16,17	1.00MXBK-ND	\$0.06	0.12	\$3.00
18	2	Resistor	YAGEO		301 OHM 1/4W 1%	R39,48	301KXBK-ND	\$0.06	0.12	\$3.00
19	8	Resistor	YAGEO		10K OHM 1/4W 1%	R38,40,47,49,72,73,78,82	10.0XBK-ND	\$0.06	0.48	\$12.00
20	1	Resistor	YAGEO		95.2KNOHM 1/4W 1%	R32	95.3KXBK-ND	\$0.06	0.06	\$1.50
21	1	Resistor	YAGEO		200K OHM 1/4W 1%	R66	200KXBK-ND	\$0.06	0.06	\$1.50
22	1	Resistor	YAGEO		402K OHM 1/4W 1%	R29	402KXBK-ND	\$0.06	0.06	\$1.50
23	4	Resistor	YAGEO		51 OHM 1/2W 5%	R42,43,64,65	51H-ND	\$0.15	0.6	\$15.00
24	2	Resistor	YAGEO		100 OHM 1W 5%	R74,75	100W-1-ND	\$0.15	0.3	\$7.50
25	3	Trimpot	BOURNS		10K OHM TRIM POT	R30,31,51	3252W-103-ND	\$14.00	42	\$1,050.00
26	11	sip	CTS		10K OHM 710A103	RP1 - RP11	750-101-R10K-ND	\$0.31	3.41	\$85.25
27	1	Capacitor	Panasonic - ECG	ECQ-B1H101KF	CAP .0001UF 50V POLY B SERIES 50V ±10%	C15	Digikey P4570-ND	\$0.11	0.106	\$2.65
28	9	Capacitor	Panasonic - ECG	ECQ-B1H221KF	CAP .00022UF 50V POLY B SERIES 10%	C43,C45,C61,C82,C121,C122,C128,C129,C130	P4574-ND	\$0.11	0.954	\$23.85
29	1	Capacitor	Panasonic - ECG	ECQ-B1H471JF	CAP .00047UF 50V POLY B SERIES Radial lead 5%	C20	P4578-ND	\$0.11	0.106	\$2.65
30	4	Capacitor	Panasonic - ECG	ECQ-B1H102JF	CAP .001UF 50V POLYESTER ±5% B Radial Bulk	C59, C137, C72, C78	P4551-ND	\$0.01	0.044	\$1.10
31	9	Capacitor	Panasonic - ECG	ECU-S2A103KBA	.010 UF 100V 10% MONOLIT CERM CAP X7R	C7,8,12,14,18,31,73,74,79	P4904-ND	\$0.07	0.63	\$15.75
32	4	Capacitor	CORNELL DUBILIER	SK220M025ST	Capacitor, Electrolytic, SK Series, Aluminum, 0.197 inch Diameter x 0.433 inch Length, 0.078 inch Lead Space, 25 WV DC, 22 micro F, +/-20 percent Tolerance	C3,9,10,85	Newark 91F6274	\$0.05	0.2	\$5.00

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Item	QTY	Part Name	Manufacturer	Part Number	description	RefDesignator	Dist/stknum	unit cost	qty 1	cost 25
33	1	Capacitor	CORNELL DUBILIER	LP472M016A1P3	Capacitor, Electrolytic, LP Series, Snap Mount, Aluminum, 0.867 inch Diameter x 1.000 inch Length, 16 WV DC, 4700 micro F +/-20 %	C4	Newark 44F1589	\$3.92	3.92	\$98.00
34	2	Capacitor	CORNELL DUBILIER	LP272M035C1P3	Capacitor, Electrolytic, LP Series, Snap Mount, Aluminum, 1.000 inch Diameter x 1.000 inch Length, 35 WV DC, 2700 micro F +/-20 %	C5,6	NEWARK 44F1604	\$4.65	9.3	\$232.50
35	5	Capacitor	Mallory	MIL-C-26655A CS13BF105K	CAPACITOR, SOLID-TANTALUM, SUBMINIATURE, 10 PCT. TOL., MIL- C-26655AMALLORY CS13BF105K, 1.0 MF, 35 WVDC	C11,13,57,58,63	STK 1425-1000	\$0.67	3.35	\$83.75
36	12	Capacitor	CORNELL DUBILIER	T352Q106K035AS	T352Q106K035AS Capacitor, Epoxy- Dipped, Solid Tantalum, 0.250 inch Dia x 0.500 inch Height, 35 WV DC, 10 micro F, +/-10 percent	C30,46,47,48,53,64,65,6 6,83, 132,133,134	NEWARK 81F4057	\$1.96	23.52	\$588.00
37	1	Capacitor			T350J476K016AS	C52		\$2.00	2	\$50.00
38	1	CAPACITOR	CORNELL DUBILIER	CD6CD050C03	SILVER MICA, MICROMINIATURE, DIPPED, 500 WVDC, CDE CD6 1 PCT. TOL., 5 PF	C56	STK 1415-3000	\$0.08	0.08	\$2.00
39	64	CAPACITOR	Panasonic - ECG	ECU-S1H104KBB	CAP CERAMIC MONO .1UF 50V 10%	C1,2,16,17, 21 - 29, C32 - 42,44, 49,50, 51,54,55,60,62, 63,67- 71,75,76,77,80,81, 84,86 - 89,92 - 95,102 -109 ,113,114,115, C119 - 126,131,135,136,139	P4923-ND	\$0.20	12.8	\$320.00
40	1	Regulator	National	MC78L12CP	LM78L12ACZ Description 12 VOLT 0.1 AMP VOLT REG TO-92	VR3	americaii	\$0.40	0.4	\$10.00
41	1	Regulator	National	MC79L05CP	LM320LZ-5.0 Description 5V .1 AMP NEG VOLT REG TO-92	VR4	americaii	\$0.40	0.4	\$10.00
42	2	Regulator	National	LM2940CT-5.0	LM2940CT-5.0 1A LOW DROP-OUT REGULATOR	VR1, VR5	LM2940CT-5.0-ND	\$1.80	3.6	\$90.00
43	1	Transistor	National	2N4403	TRANSISTOR, SILICON, HIGH SPEED SWITCH, PNP POLARITY, VCBO 60, VCEO 40, HFE 100/300 AT 150M, 200 MHZ, 2N4403	Q1	1495-150000	\$0.04	0.04	\$1.00
44	2	Zener Diode	Microsemi Corp	1N4746	ZENER DIODE 18V 5% 1.0W DO-41	CR7,8	americaii	\$0.03	0.06	\$1.50

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Item	QTY	Part Name	Manufacturer	Part Number	description	RefDesignator	Dist/stknum	unit cost	qty 1	cost 25
45	6	Diode		IN4002	DIODE, RECTIFIER, SILICON, 100 VR, 1.1 VF, 1.0 IO, .03 IR, 30 IFSM,1N4002	CR1 - 6	1445-240000	\$0.01	0.06	\$1.50
46	1	Volt Ref	Zetex	ZRA245Y01	PRECISION VOLTAGE REFERENCE 2.45V TO-92	CR16	Digikey ZRA245A01-NI	\$1.23	1.23	\$30.75
47	1	Xfmr	PCA	EP15767	EP15767 Pulse transformer 2:1:1 500 .360 .800 5000mh	T2	PCA Electronics	\$1.70	1.7	\$42.50
48	1	arrestor	Sankosha	3YVJ-90B-J3	Three Electrode Gas Tube Arresters 90V 5mm 3YVJ SERIES	E1	Sankosha	\$8.45	8.45	\$211.25
49	10		APW Electronic Solutions/Vero	Test Points	20-2136J	TEST PTS	DIGI-KEY 233-1054-N	\$0.12	1.2	\$30.00
50	2	dip switch	Grayhill	76-PSB08S	76-PSB08S DIP Switch, 76 Series, SPST, Piano-Dip , 8 Switch Positions, 0.88 inch Switch Length, Sealed	S1,S2	americaii	\$2.75	5.5	\$137.50
51	3	LED	Chicago Miniature	CMW01G	CMW01G LED GREEN T1 MODULAR DIFFUSED	CR9 - 12	DIGI-KEY CMW01G-N	0.66	1.98	\$49.50
52	1	LED	Chicago Miniature	CMW01R	CMW01R LED RED T1 MODULAR DIFFUSED	CR13	DIGI-KEY CMW01R-N	0.62	0.62	\$15.50
53	2	LED	Chicago Miniature	CMW01Y	CMW01Y LED YELLOW T1 MODULAR DIFFUSED	CR14,15	DIGI-KEY CMW01Y-NI	0.66	1.32	\$33.00
54	1	Xfmr	Signal transformer	DMPC-Y-15	DMPC-Y-15 Transformer 10 pin 115v input secondary 5v and 15V output	T1	Signal transformer	\$16.10	16.1	\$402.50
55	1	filter	Tyco / Corcom	Tyco 1609059-1 / 3EX1	2JX5302A RFI FILT 3EX1 Line Filter	FL1	Newark 50F8813	\$11.11	11.11	\$277.75
56	1	mov	LITTELFUSE	V130LA10A	V130LA10A MOV Metal-oxide varistor, 14mm-diameter disc, 130VAC/175VDC	R1	NEWARK 09F1979	\$0.67	0.67	\$16.75
57	1	Fuseholder	Bussman	BK/HBH or HBH-I	PCB Block Fuse Holders, Horizontal M	F1	NEWARK 46F019	\$4.31	4.31	\$107.75
58	1	Fuse	LITTELFUSE	312001	Fast Acting Fuse, 1/4 inch x 1-1/4 inch, 3 AG, 250 volt, 1 Amp	F1	NEWARK 27F656	\$0.22	0.22	\$5.50
59	1	Connector	Positronic Ind	DPB9FN7T2 / 9FNT2X	DPB9FN7T2/9FNT2X	P4,9	Positronics	\$16.49	16.49	\$412.25
60	4	Connector	Positronic Ind	DPB37FN7T2 / 37FN7T2X	DPB37FN7T2 / 37FN7T2X	P2/7,P3/8,P5/10, P6/11	Positronics	\$22.57	90.28	\$2,257.00
61	2	Connector	Amp/Tyco	#222392-1	#222392-1 triaxial r/a connector	CONN A, B	Amp	\$5.00	10	\$250.00
62					CMT12		DIGI-KEY		0	\$0.00
63					FHS-440-4				0	\$0.00
64					4-40 LOCK NUT		STK		0	\$0.00
									0	\$0.00

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Item	QTY	Part Name	Manufacturer	Part Number	description	RefDesignator	Dist/stknum	unit cost	qty 1	cost 25
65	3	dip8 socket	RN / 3M	ICO083-S8-TG OR AMP 2-64126O-4	SOCKET, INTEGRATED CIRCUIT, DIP, RN P/N, 8 CONTACTS,,300 IN. CENTERS	U26,U56,U59	Stk 1455-605000	\$0.29	0.87	\$21.75
66	14	dip14 socket	RN / 3M	ICO133-S8-TG OR AMP 2-641609-4	SOCKET, INTEGRATED CIRCUIT, DIP14 CONTACTS,,300 IN	U30,U44,U31,U55,U58,U 57,U13,VR2,U3,U4,U61, U29,U38,U53	Stk 1455-606000	\$0.31	4.34	\$108.50
67	10	dip16 socket	RN / 3M	ICO163-S8-TG OR AMP 2-641610-4,	SOCKET, INTEGRATED CIRCUIT, DIP, SOLDER TAIL 16 CONTACTS,,300 IN. CENTERS	U60, U20, U10, U25, U23, U63, U12, U1, U17, U6	STK 1455-607000	\$0.26	2.6	\$65.00
68	10	dip20 socket	RN / 3M	ICO203-S8-TG OR AMP 2-641612-4,	SOCKET, INTEGRATED CIRCUIT, DIP, SOLDER TAIL 20 CONTACTS,,300 IN. CENTERS	U64, U14, U8, U7, U16, U9, U19, U18, U15, U5	STK 1455-608000	\$0.40	4	\$100.00
69	15	dip24 socket	RN / 3M	RN P/N ICO243-S8-T	SOCKET, INTEGRATED CIRCUIT, DIP, SOLDER TAIL, , 24 CONTACTS,,300 IN. CENTERS	U48, U22, U52, U37, U47, U32, U54, U39, U21, U11, U40, U33, U49, U43, U24	1455-609500	\$0.24	3.6	\$90.00
70	11	dip28 socket	RN / 3M	ICE-286-S-TG	Machine Dip Socket, ICE Series, Screw Machine, 28 Contacts 0.6 row spacing	U27, U34, U28, U45, U50, U46, U51, U35, U11, U36, U42	NEWARK 04F763	\$0.38	4.18	\$104.50
71	1	dip40 socket	RN / 3M	ICE-406-S-TG	Machine Dip Socket, ICE Series, Screw Machine, 40 Contacts, 0.6 row spacing	IC SOCKET	NEWARK 04F765	\$0.63	0.63	\$15.75
72	2	dip4socket	Tyco / augat	504-AG11D	Crystal Oscillator Socket, 504 Series, Tin/Lead Sleeve Plate, 4 Contact	X1,X2	Newark 94F3802	\$1.20	2.4	\$60.00
73	1	IC	ROCHESTER	COM1553B	1553B COM Controller	U2	Rochester Electronics	\$199.00	199	\$4,975.00
74	1		HARRIS		CD74HCT08E	U3	Americaii	\$0.10	0.1	\$2.50
75	1		RCA		CD74HCT14E	U4	Americaii	\$0.13	0.13	\$3.25
76	1		TAXE INST		SN74HCT645N	U5,15	Americaii	\$1.25	1.25	\$31.25
77	1		TI		74HCT139N	U6	Americaii	\$0.10	0.1	\$2.50
78	7		National		74HCT541N	U7,8,9,14,18,19,64	Americaii	\$0.19	1.33	\$33.25
79	1		SIGNETIC		74HCT4538N	U10	Americaii	\$0.30	0.3	\$7.50
80	4		ICT	PEEL173P / PA7540P	PA7540 PEEL Array™ Programmable Electrically Erasable Logic Array	U11,21,40,43	Jaco electronics	\$2.62	10.48	\$262.00
81	1		PHILIPS		74HCT174	U12	Americaii	\$0.22	0.22	\$5.50
82	1		Fairchild		CD74HCT74E	U13	Americaii	\$0.10	0.1	\$2.50
83	1		National		74HCT540N	U16	Americaii	\$0.20	0.2	\$5.00
84	2		HARRIS		CD74HCT193E	U17,23	Americaii	\$0.59	1.18	\$29.50
85	2		HARRIS		CD74HCT4538E	U20,25	Americaii	\$0.64	1.28	\$32.00
86	2		VTC	V74ACT827PS	Buffer tri-sate 10 bit non-inverting	U22,U48	Americaii	\$1.50	3	\$75.00
87	1		MAXIM		MAX162ACNG High speed CMOS 12 Bit ADC	U24	Maxim Direct 888.629.4642	\$40.50	40.5	\$1,012.50
88	1	dip8/3	HARRIS-Intersil	ICM7555IPA	Time Delay Generation CMOS RC timers ICM7555IPA	U26	Avnet Electronis	\$0.25	0.25	\$6.25

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Item	QTY	Part Name	Manufacturer	Part Number	description	RefDesignator	Dist/stknum	unit cost	qty 1	cost 25
89	2	dip28/6	Analog Devices	AD664BD-BIP	AD664 four complete 12-bit, voltage-output DACs on one monolithic IC chip. Each DAC has a double-buffered input	U27,U34	Newark	\$107.37	214.74	\$5,368.50
90	9	dip28/6	HARRIS-Intersil	HI-507A-5 or HI1-0547-5	Single 16 and 8, Differential 8-Channel and 4-Channel CMOS Analog MUXs with Active Overvoltage Protection 28 CDIP 0+75 15.0V DIFF. 8-CHAN. O.V	U28,35,36,41,42,45,46,50,51,54	Newark 05B6892	\$12.90	116.1	\$2,902.50
91	1		AD		AD521KD	U29	Newark 05F6903	\$44.50	44.5	\$1,112.50
92	1		PHILIPS		75450BN	U30	Rochester Electronics	\$1.50	1.5	\$37.50
93	1		PHILIPS		NE521N	U31	Americaii	\$1.99	1.99	\$49.75
94	8		PHILIPS	74HCT652N	74HCT652N OCTAL XCVR/REGISTER 3-STATE	U32,33,37,39,47,49,52,5	Avnet Electronis	\$0.70	5.6	\$140.00
95	1		HARRIS		74HCT125E	U38	Second Source Electronic	\$0.33	0.33	\$8.25
96	2		HARRIS		74HCT04E	U44,57	Second Source Electronic	\$0.15	0.3	\$7.50
97	1		HARRIS		74HCT125E	U53	Second Source Electronic	\$0.33	0.33	\$8.25
98	1		PHILIPS		74HCT393N	U55	Second Source Electronic	\$0.27	0.27	\$6.75
99	1		Maxim / Dallas	DS1231-20N	DS1231-20N IC POWER MONITOR 20NS IND 8-DIP	U56	Digikey DS1231-20N-ND	\$4.50	4.5	\$112.50
100	1		HARRIS		CD74HCT00E	U58	Second Source Electronic	\$0.18	0.18	\$4.50
101	1		Analog Devices	OP77FZ	OP77FZ Ultralow Offset Voltage Operational Amplifier	U59	Pioneer Electronics	\$4.72	4.72	\$118.00
102	1		Harris / Philips	74HCT40103E or 74HCT40103N	74HCT40103E	U60	Second Source Electronic	\$0.76	0.76	\$19.00
103	1		Harris	74HCT242N	74HCT242N	U61	Second Source Electronic	\$3.25	3.25	\$81.25
104	1		TI	LM318P	IC SINGLE HS OP AMP 8-DIP Small-Signal Bandwidth . . . 15 MHz Typ Slew Rate 50 V/ms Min Bias Current . . . 250 nA Max	U62	digikey 296-9539-5-ND	\$0.75	0.75	\$18.75
105	1		SIGNETIC		74F3037N	U63	Second Source Electronic	\$1.76	1.76	\$44.00
106	1	Osc12M	RALTRON	CO1100-12.000-MHZ	Clock Oscillator, TTL Compatible, 14 Pin DIP Style, 12.000 MHz	X1	Newark 96F2820	\$2.50	2.5	\$62.50
107	1	Osc4M	Epson	SG-51P 4.000MC	4.000MC CMOS OSC OE 4.0000 MHZ	X2	Digikey SE1703-ND	\$1.74	1.74	\$43.50
109	1	dip14/3	National	LM325N	LM325N Dual 15 volt regulator dip	VR2	Rochester Electronics	\$10.85	10.85	\$271.25

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Item	QTY	Part Name	Manufacturer	Part Number	description	RefDesignator	Dist/stknum	unit cost	qty 1	cost 25
110	9		SPC CONNECTORS	SPC-2421	Threaded Female/Female Hexagonal Spacer 1.000 inch Length, 1/4 inch Outside Diameter, No. 4-40 Thread, Nylon 6/6, Rated UL94V-0, White \$23.89		Newark 92N4926	\$0.24	2.16	\$54.00
111	1				Printed Circuit Board			\$80.00	80	\$2,000.00
112	1				Chassis			\$112.00	112	\$2,800.00
113	1				assembly			\$150.00	150	\$3,750.00
							Total Cost			
							Cost per unit		\$1,325.05	\$33,126.25